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TRENDS IN MODERN CHEMISTRY

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The great achievements of present-day chemistry are based on experience gained in the past 100 to 150 years. The greatest development has occurred in the 20th century. During this period of development the world was introduced to such famous Soviet scientists and chemists as Lomonosov, Mendeleyev, Butlerov, and others. The most remarkable development, however, was seen in the field of organic compounds. Therefore, it is now possible to use many cheap and plentiful organic compounds instead of scarcer and more expensive compounds. This has been accomplished by extensive exploitation of raw-material sources such as oil, coal, and natural gas. Much has also been accomplished in the field of high-molecular compounds. Many improvements have been made in such chemical fields as catalysts, super pressures, photochemical radiation, deep freezing, etc. However, the most important achievement was the discovery of methods for using intra-atomic, nuclear energy. Some of the problems Soviet chemists hope to solve in the near future are as follows:

Development of Raw-Material Sources for the Chemical Industries

Studies in this field have two objectives: (1) better exploitation of the more common elements, and (2) better utilization of the rarer elements. At present, it is difficult to point out any particular element and say that it is not being utilized in one or another of the technological or scientific fields. Not so long ago, four new elements were discovered: neptunium (93), plutonium (94), americium (95), and curium (96). Since the discovery of uses for isotopes, the known elements can be used in many hundreds of new ways. The chemical industry is also making good use of such unlimited resources as air, natural gases, sea water, etc.

There appears to be a tendency to utilize elements which have high Clarke numbers. (Numbers determining in percent the proportional content of a given element in a given cosmic body or part thereof; some of these elements, are

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aluminium (7.5 Clarke), silicon (26 Clarke), sodium (2.4 Clarke), and others).

Until recently there was no full utilization of raw materials. In many industries by-products were considered waste. Now, for example, in the sulfuric acid industry, many valuable by-products such as gold, arsenic, selenium, tellurium, and thallite are obtained. Many of these by-products are more valuable than the principle product; thus, one kilogram of thallite is 5,000 times more valuable than the same amount of sulfuric acid, and selenium is about 300 times more valuable than an equivalent amount of sulfuric acid.

Animal and plant life resources are diminishing, while the mineral resources are still relatively untouched. Consequently, present-day chemical science is interested in replacing organic raw-material sources by mineral resources. For example, ethyl alcohol was at one time produced only from grain or potatoes. Now, due to chemical progress, it is possible to manufacture this alcohol from crude oil, wood, or from cellulose and paper by-products. Synthetic rubber manufactured from acetylene obtained from calcium carbide is replacing natural rubber in many fields.

To further illustrate the great economies obtained, the following example is given. Alcohol is required in the manufacture of high-grade synthetic rubber. Some 2.2 tons of alcohol are necessary to produce one ton of rubber. Eight to nine tons of rye or 22 tons of potatoes are necessary to produce 2.2 tons of alcohol. Thus, if the synthetic rubber industry uses wood alcohol, or alcohol obtained from crude oil, the peoples of the Soviet Union will be able to convert an additional 8 hectares of rye or 2 hectares of potatoes into food rather than into industrial products.

Synthesis of New Chemical Products

Because of the great achievements in the synthesis of new chemical products the present century has often been termed the "Synthetic Chemistry Century."

Usually, organic compounds are the result of synthesis. Some of the better known ones are tetraethyllead (TES) and insecticides and fungicides. Much has been accomplished in the field of metallo-organic compounds. Scientists active in this last field are A. N. Nesmeyanov, K. A. Kochetkov, and others.

Technological progress is constantly requiring new developments in the field of chemistry. The development of jet engines heralded the study of new fuel substances which would meet the operational demands of jet engines. Contemporary medical science owes much to achievements in the field of chemistry.

One vital task facing present-day Soviet chemists is the determination of the relationship between the various properties of a given substance, by studying its nature and structure. Academician N. S. Kurnakov's discovery of physical chemical analysis is being well utilized toward the determination of the above relationships.

The USSR is witnessing the growth of a new field of illumination engineering, based on the discovery of luminescent tubes by Academician S. I. Vavilov and others.

Construction of machinery for the chemical industry requires new materials as well as new designs. Equipment has to be resistant to high temperatures and pressures, as well as powerful acids. Now it is possible to manufacture fibers of polyamide resins like nylon and caprone.

The study of chemistry of hydrocarbons has always been a field in which Russian chemists have excelled. For example, there are the schools founded by A. M. Butlerov, A. Ye. Favorskiy, N. D. Zelinskiy, and others. One major task in this field is the determination of developing hydrocarbons and convincing various industires of the value of using such intermediate products as methane, acetylene, etc.

Wood or methyl alcohol was formerly manufactured by burning wood. Now, alcohol is manufactured by synthesizing oxides of carbon and hydrogen. Acetic acid, acetone, ethyl alcohols, and many other products are now being manufactured synthetically form minerals rather than from plant matter. Great strides are being made to synthesize such basic substances as vitamins, hormones, and fats.

Much work still has to be done to determine the nature of the complex structure of albumin, as well as the very difficult task of synthesizing this material.

Of particular interest are the analogs of many natural compounds, particularly those which have medicinal value.

There is also a rapidly growing production of sex hormones. Research is being carried out on the possibility of synthesizing antibiotics such as penicillin, gramacidin, streptomycin, and others.

Modern chemical technology has made possible the manufacture of many different types of plastics with some remarkable properties. For example, a plastic mass of polychlorovinylidenochloride will withstand loads of 7,000 kilograms per square centimeter. S. V. Lebedev, G. S. Petrov, S. N. Ushakov, and their coworkers have been very active in this field.

The use of rare metals in alloys increases their hardness, chemical stability, and heat resistance. This is an important technological development which can be well used in the production of defense items in electrical engineering, illumination engineering, medicine, analytical chemistry and other fields.

There is particularly great interest in the heavy radioactive elements -- thorium, uranium, neptunium, plutonium and others -- due to their practical importance in utilization of nuclear energy.

Production of new silicate and ceramic materials is progressing rapidly. The theoretical groundwork is in progress for the synthesis of these materials which will result in higher technical qualities. New methods are being evolved for obtaining the so-called glass ceramics -- fireproof, chemically stable, porous, ultra-hard -- uviol, and "clarifying" glass, etc. K. A. Andrianov has made great progress in work on the synthesis of silicon-organic compounds with rubberlike properties, stability under various temperature conditions, and other valuable properties.

Development of New and Improvement of Old Production Processes

In the last 10 years many new methods have been developed for bringing about chemical reactions. One of the best known methods is the use of catalysts. In addition, technology has developed methods for obtaining very high pressures. Excellent results have been obtained by the combined use of catalysts and high pressure. Methods have also been developed for obtaining very high temperatures as well as almost absolute vacuums.

Further increase of production is dependent upon studies of the best physical and chemical conditions necessary for various production processes.

Research is still necessary to determine methods for utilizing atomic energy in chemical and technological processes. Much has yet to be learned about atomic energy, and it is suggested that further research be conducted with the view of determining methods for: (1) regulation and gradual utilization of atomic

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energy, (2) establishing the sphere of activity of atomic energy and protecting workers from the harmful effects of radiation, and (3) developing and discovering new raw-material sources.

Developments in the chemical field have been greatly aided by achievements in other fields. The discovery of the electron microscope was a valuable addition to the equipment used in chemical technology. More recently, the cyclotron and betatron have taken their place among the various technical aids available to the Soviet chemist.

New Methods of Analysis and for Controlling Production Processes

Two tendencies are very evident in present-day analytical chemistry: (1) great development of physical and physicochemical methods, and (2) direct determination of chemical elements and compounds. Much work is presently being done in the analytical chemistry of rare elements. It must be remembered that chemistry is very closely allied to other fields of science and that a good analytical chemist must also be a good physicist and physical chemist. The introduction of physical and physicochemical methods into analytical chemistry in many cases permits continuous and automatic control of production processes.

Study of the Structure of Matter; Intra-atomic and Molecular Processes

Solution of problems dealing with atomic energy is dependent on a good understanding of the structure of the atom as well as intra-atomic processes. It was not until very recently that scientists began to study the atom from the chemical point of view.

Closely related to the study of atomic energy is the study of the nature and properties of isotopes. Future research should attempt to solve problems dealing with the concentration of isotopes so that they can be better utilized.

The use of wave mechanics and electron theories permitted a new approach to Mendeleyev's classification of elements. Soviet chemistry has been furthered by the discoveries of Mandel'shtam and Landsberg in the field of the combined diffusion of light. Many large schools of science, led by such able men as Academician I. V. Grebenshchikov, A. N. Frumkin, P. A. Rebinder, and others, are making important discoveries in the field of colloidal chemistry and in the study of surface phenomena. N. A. Shilov and M. M. Dubinin have done much valuable work with the theory of sorption processes.

Study of the Mechanism and Kinetics of Chemical Reactions

In spite of large production of chemical compounds, many of the reactions which form these compounds have not been studied. For most of the reactions, only the initial and final processes are known while the intermediate processes are unknown. However, the use of photochemical methods has permitted scientists to study many of the intermediate processes. Those dealing with chemical kinetics have the task of classifying the basic reactions in the fields of organic and inorganic chemistry. Academician N. N. Semenov has already accomplished much work in this field.

Much research is being carried out to determine the nature of the propagation of blast gases and the effective distances of blast flames. This subject is particularly important for a fuller understanding of combustion processes which occur in an internal combustion engine. Data thus obtained will also be valuable for determining the ideal fuel for rockets and jet engines. Much research is being carried out to determine methods for intensifying the combustion processes of solid fuels.

Soviet chemistry has indeed led the world in the study of catalysts and catalyctic processes. Such people as N. D. Zelinskiy, A. A. Balandin, A. Z. Roginskiy, and others have built up noteworthy organizations for studying catalysts and their activity.

Application of Chemistry to Other Fields of Science, Engineering, and to the National Economy

The development of Soviet chemistry during the next 5 years will be very closely connected to the general over-all development of the national economy. It is hoped that by 1950 the chemical industry will have grown 1.5 times over the prewar level. The production of phosphate fertilizers must more than double prewar production, while nitrogen fertilizers must exceed prewar production by 80 percent. New developments have to be exploited by the chemical industry; for example, there must be greater production of double superphosphate, greater use of nitric acid processing of phosphates, and a greater production of potassium salts and complex nitrogen fertilizers.

Present plans call for a 1950 production of synthetic rubber which will be double that of prewar. This would mean that synthetic rubber would make up 38 percent of the total rubber production in 1950.

The petroleum industries have been given the task of improving high-octane gasolines. To accomplish this it will be necessary to build four crude oil cracking plants and 16 oil refineries.

It is hoped that by 1950 there will be a yearly production of 920 million cubic meters of gas obtained by underground gasification. By then, chemical industries must perfect methods for obtaining 900,000 tons of liquid fuel from coal and shale.

The Five-Year Plan for the lumber industry calls for greater production of acetic acid, rosin, acetate solvents, and turpentine. Production in 1950 of alcohol by hydrolysis is to be seven times as large as prewar production.

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